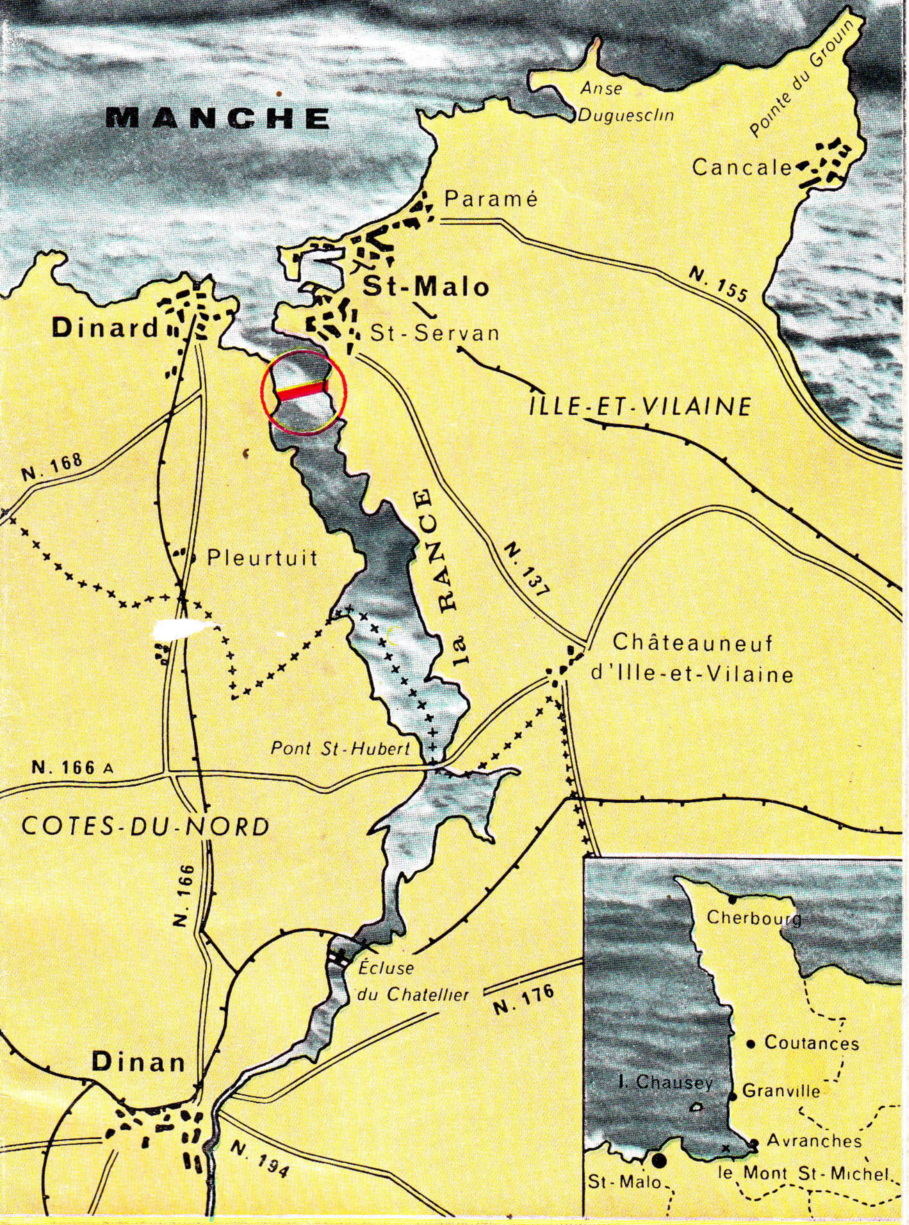
ANGLAIS

usine marémotrice de la RANCE

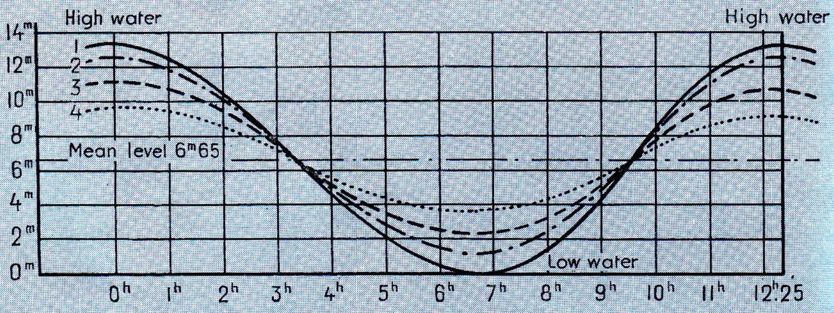


ÉLECTRICITÉ DE FRANCE
Région d'équipement marémotrice
44 rue de Courcelles. Paris-8 - Tél. MAC. 34-90 • La Corbinais-Dinard Tél. 46-15-15

LOCAL TIDES

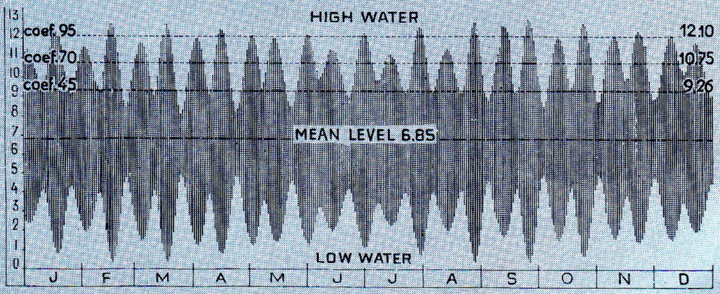
- The Brittany coast on the English Channel is one of the regions in the world where the tides are the strongest. This is doubtless due in part to the barrier formed by the Cotentin peninsula to the tide wave sweeping in from the Atlantic.
- In the Rance estuary the difference between the level of consecutive high and low water may be as much as **13,5 m.**
- The tides are of the semi-diurnal type. There are two high water and two low water in 24 hours 50 minutes.

Ranges



1 - Exceptional equinoctial spring tide
2 - Medium spring tide
3 - Medium tide
4 - Medium neap tide

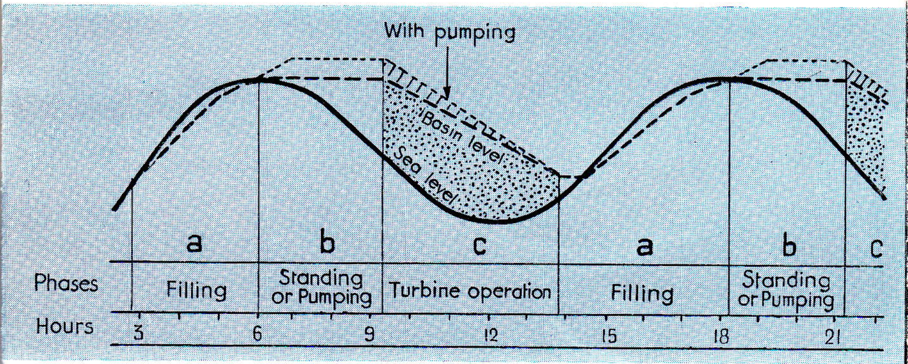
Tides during the year 1961



- During the equinoctial spring tide the **maximum flow** in the Rance during flow or ebb reaches **18000 m³/sec,** or about 3 times the flow of the Rhône in flood at Avignon.

In the most simple power station the method is to fill and empty the basin (estuary) successively, by means of **turbines** and **sluices.**

Single-way operation on emptying



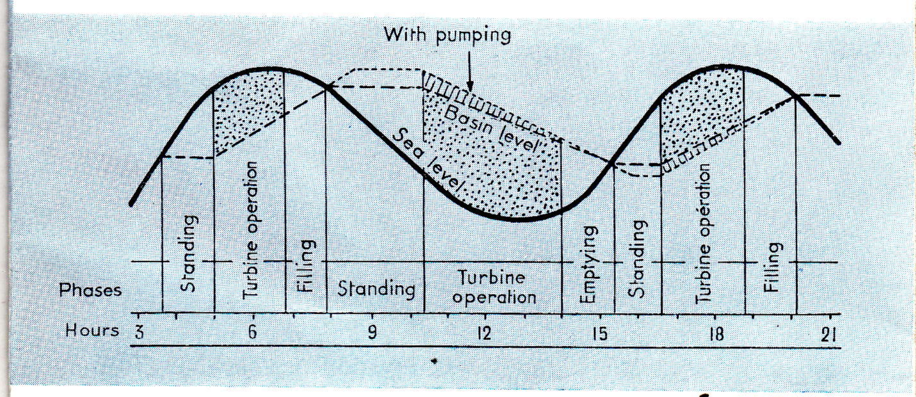
- On the rising tide the basin is filled by opening the sluices. When the tide is at full the sluices are closed and **the basin is not emptied by the turbines** until the ebb has created an adequate head.
- This is the simplest form of using tidal energy which was formerly used in tidal mill wheels.
- This cycle can be improved by using the energy available on the network during slack hours **to pump** the sea water into the basin to raise the level and increase the volume of water available for the turbines.

Single-way operation on filling

In this case, the energy is produced by passing the water through the turbines on the rising tide, from the sea towards the basin, thus **filling** the latter.

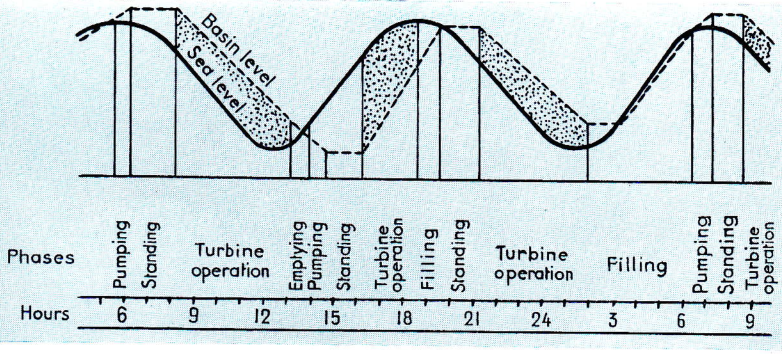
Double-way operation

This is the combination of the two preceding cycles. The energy is produced during **both filling and emptying of the basin.**



Sesqui operation

This cycle consists in making use of two successive spring tides to pass the water **three times through the turbines** (whence the name "sesqui operation" or 3/2 operation), with **two intermediate pumpings** which improve the volume of water subsequently available to the turbines.

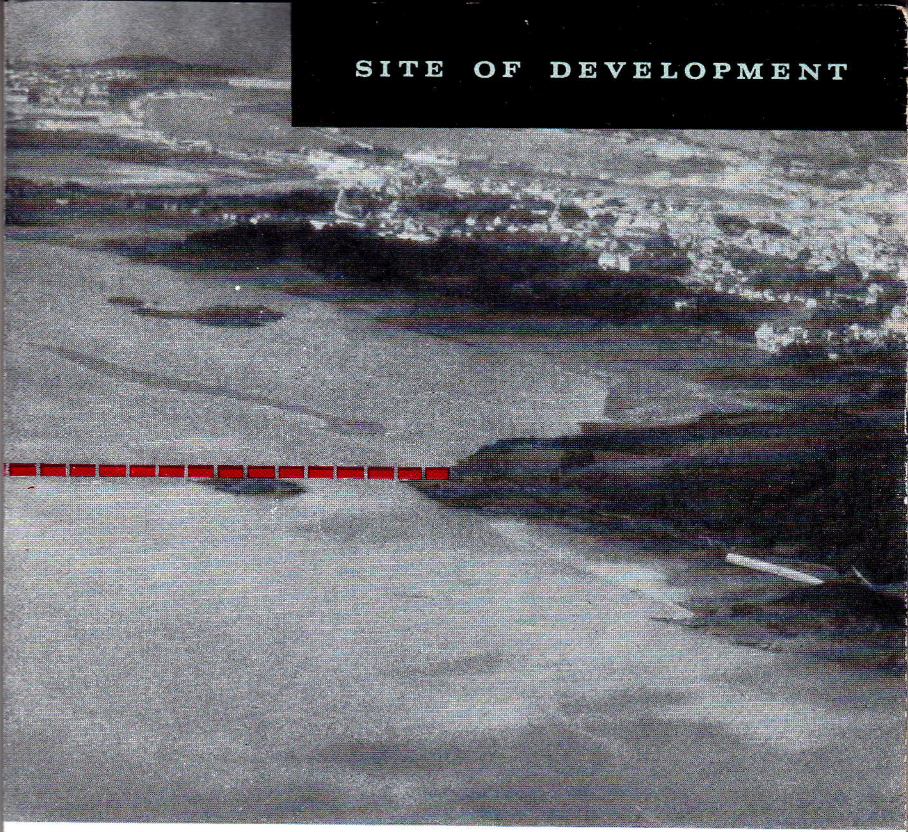


Among the numerous cycles available to the operator, he will select the one which is best adapted to the tidal range and the amount of energy at various times of the day. To ensure a constant cost of energy, the most favourable cycle would be :

- for small tides : repeated single-way operation with pumping ;
- for medium tides : repeated double-way operation with pumping;
- for strong tides : sesqui operation with pumping;
- for exceptional tides : double-way operation without pumping.

It follows that by using **double-way operation** *and* **pumping** *a* "**made to measure**" *operation can be ensured according to the hours and the tidal range. In this way, the endency is to abandon the lunar tide rhythm to approach the solar rhythm which is that governing human activity.*

SITE OF DEVELOPMENT



- The tidal power station is sited between the **Briantais Point,** right bank and the **Brebis Point,** left bank where the Rance is about 750 m wide.

  The lay-out straddles the **Chalibert rock.**

- Soundings have shown that the river bed consists of granitic rock covered in places by sand and pebbles.

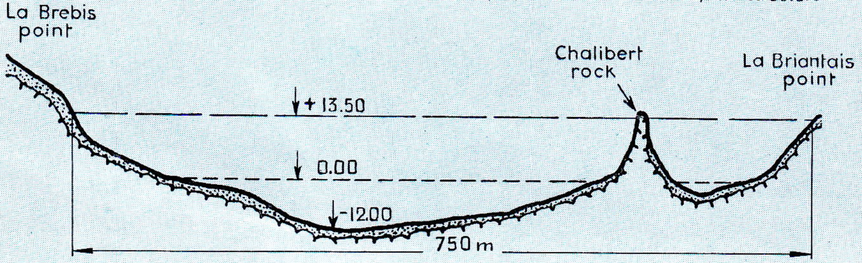
  The greatest depth is 12 m below the zero of the sea charts.

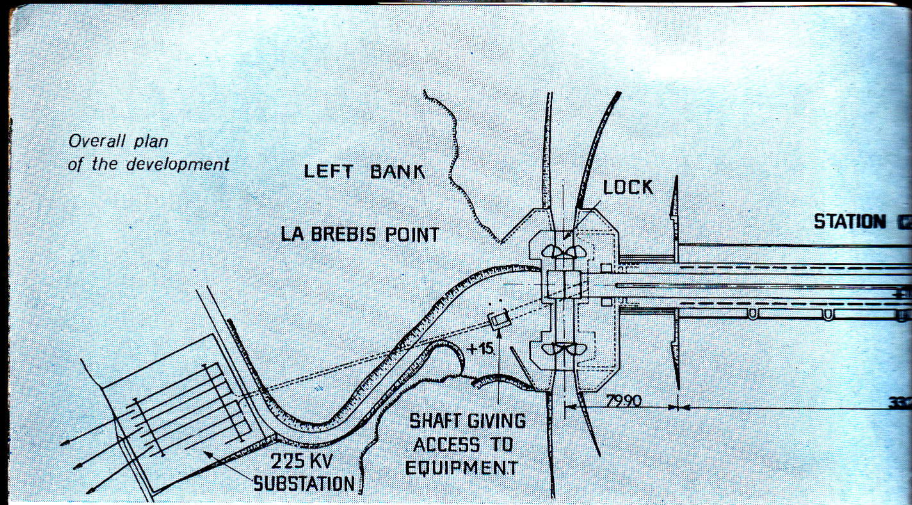
- The storage reservoir extends as far as **Le Chatellier lock** near **Dinan,** over some 20 km.

Area of basin (at + 13,5 S. C.) **22 km²**

Useful volume of basin : 184 millions cubic metres
(between + 0,00 and + 13,50 S C.)

Terrain profile at the centerline of the structure





Overall plan of the development

Starting from the left ba

1 the lock

Implanted in the Brebis point. Length of lock-chamber 65 m, width 13 m. Apron at level + 2,00 S.C.

2 the power station

Situated in the deep part of the Rance.

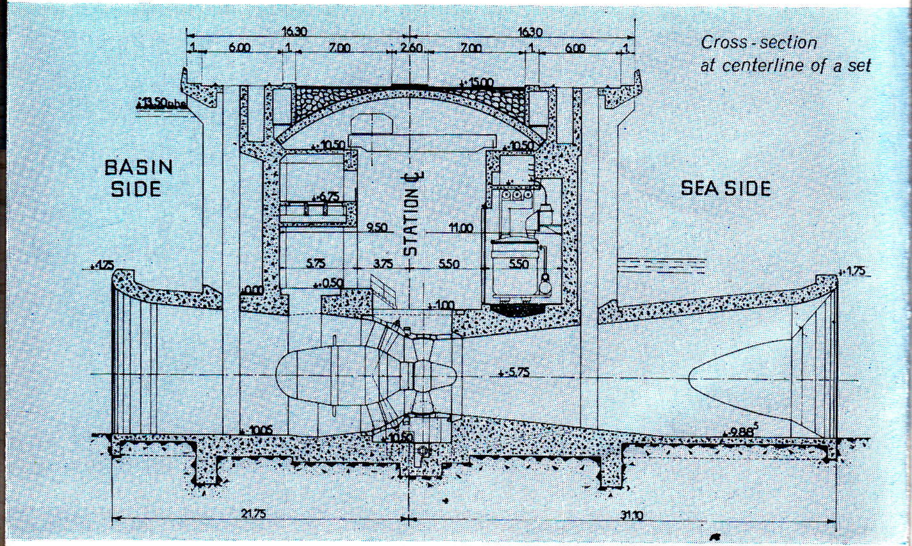
It consists of a hollow concrete dike, the up-stream and downstream faces of which are reinforced by buttresses 13,30 m apart.

The roof formed by an arch sets up thrusts in the opposite direction to that of the flow.

length approximately 390 m,
total width : 53 m.
Crest level + 15.00 S.C.
foundations at about - 10.00 S.C.

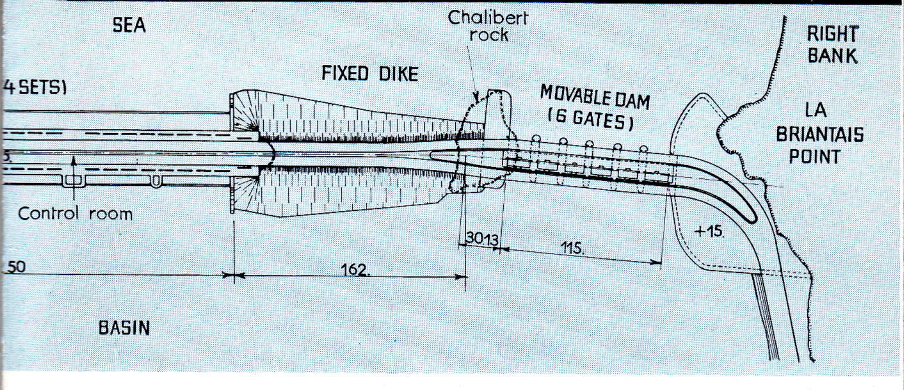
Inside are installed

24 bulb sets of 10 MW
3 transformers of 80 MVA (225 kV)
4 travelling cranes of 90 t



Cross-section at centerline of a set

BRIEF DESCRIPTION OF THE STRUCTURES



...k, the structures comprises:

the power station (continued)

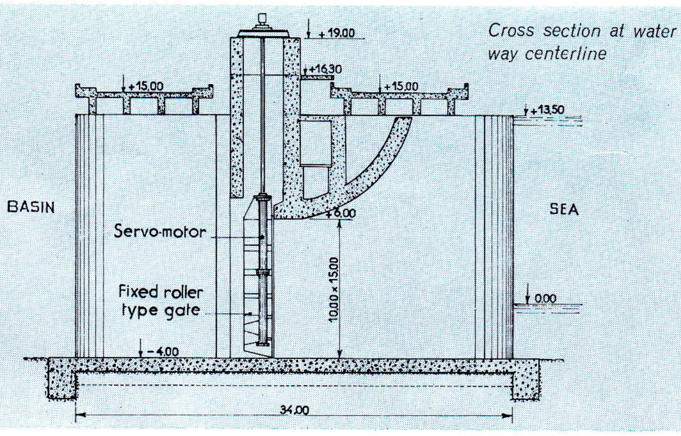
- Each transformer, situated in a bay especially enlarged on the side towards the sea, is fed by a battery of 2 × 4 sets.
- 225 kV oil-insulated cables connect the transformers to an **outgoing station** situated on the left bank.
- **Access to the power station** is by a shaft situated on the left bank and a gallery passing under the lock.

3 **the fixed dike**

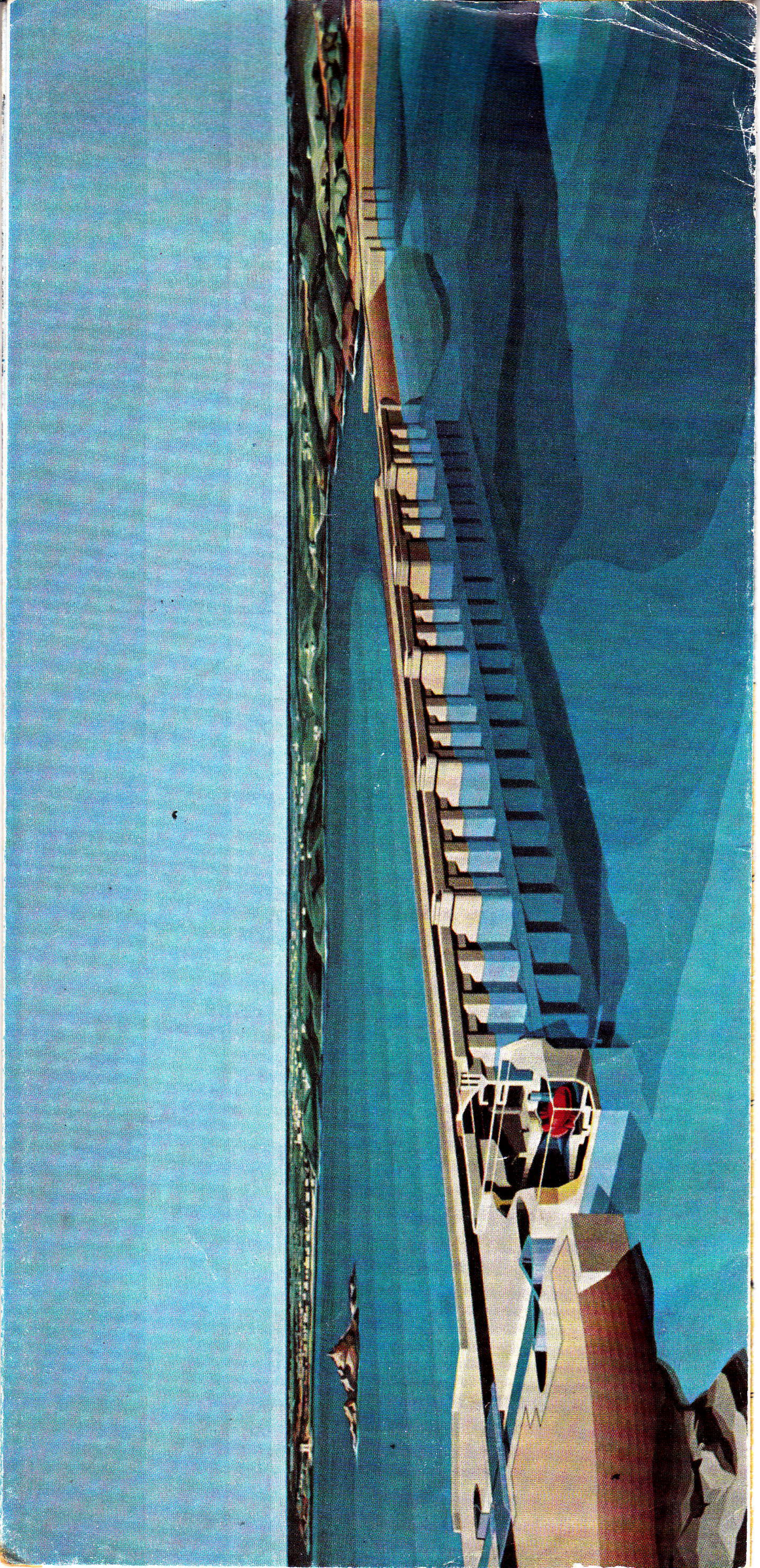
Connecting the eastern end of the power station with the Chalibert rock. Length approx. 175 m.

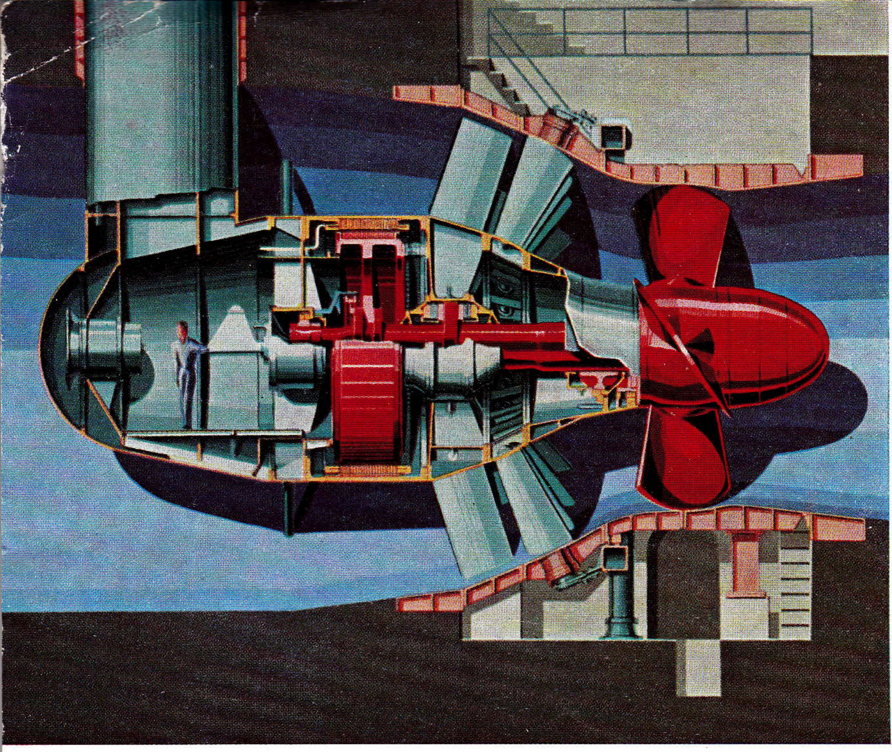
4 **the movable dam**

Situated between the Chalibert rock and the right bank.
Length 115 m
Apron level — 4.00 S. C.
6 fixed roller gates, width 15 m, height 10 m.



All of these structures are levelled out at + 15 S.C. and will enable a main highway to be laid subsequently, thus facilitating traffic between the two banks of the Rance.





Rance Bulb Set

THE BU

It is composed **of a metal ogee shell containing the A. C. generator and a Kaplan turbine.**

The assembly is placed in a horizontal duct.

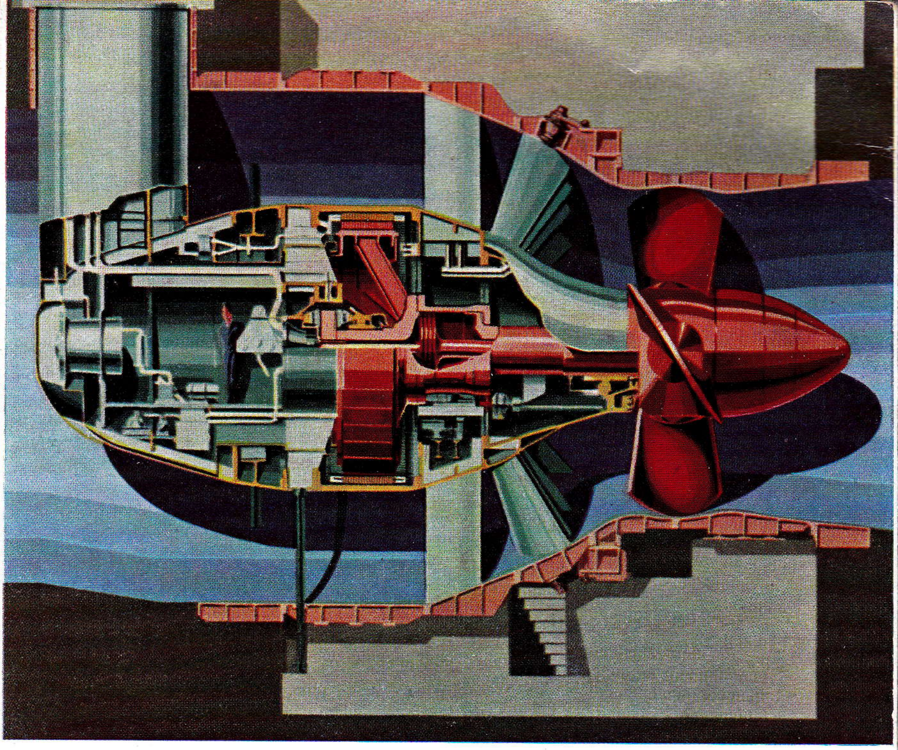
The fixed guide vanes serve as support.

A shaft leading to the machine room gives access to the shell.

The set operates either as a **turbine** or as a **pump** and **in both directions of flux.**

Characteristics

Turbine	Kaplan wheel with adjustable runner blades and guide vanes Number of runner blades : 4 Diameter of wheel : 5,35 m Capacity : 10 MW Speed : 94 r. p. m. Runaway speed : 380 r. p. m.
A. C. Generator	Directly coupled to the turbine Rotating in air at an absolute pressure of 2 kg/cm² Capacity : 10 MW at Cos φ = 1



Saint-Malo Bulb Set

LB SET

Operation as a turbine		under a head of :				
		11 m	9 m	7 m	5 m	3 m
Direct (Basin to sea)						
Capacity	MW	10	10	10	8	3,2
Flow absorbed	m³/sec	110	130	175	260	200
Reversed (sea to basin)						
Capacity	MW	10	10	9,5	5,5	2
Flow absorbed	m³/sec	130	155	230	195	135

Operation on direct pumping		under a head of		
		1 m	2 m	3 m
Direct (sea to basin)				
Maximum pump output	m³/sec	225	195	170

The design of the Rance set is the result of data gathered from axial bulb sets installed in the rivers :

- Truyère at **Cambeyrac** (two 5 MW sets)
- Dordogne at **Argentat** (one 14 MW set)
- Isère at **Beaumont-Monteux** (one 8,5 MW set)

and more recently at **Saint-Malo** where a **veritable tidal power generating set** has been installed in a dis-used lock of the port. Its characteristic features approximate very closely those of the group which will be operated in the Rance.

(**Saint-Malo set :** 9 MW - 88 r.p.m. - wheel diameter : 5,80 m)

The final structures will be **erected under dry conditions,** inside **three enclosures formed by coffer-dams.**

1st stage

Will cover :

- **One left bank enclosure** to permit of constructing the lock ;

  This enclosure will be constituted by concrete walls according to the tide and will be incorporated in the final structure, crest level + 14.00 S. C.

- **One right bank enclosure** supported on the Chalibert rock to permit of constructing the movable dam.

  Enclosure consisting of flat web sheet-piling gabions filled with sand.

  Gabion diameter 16 to 19 m. Crest level + 14.00 S. C.

2nd stage

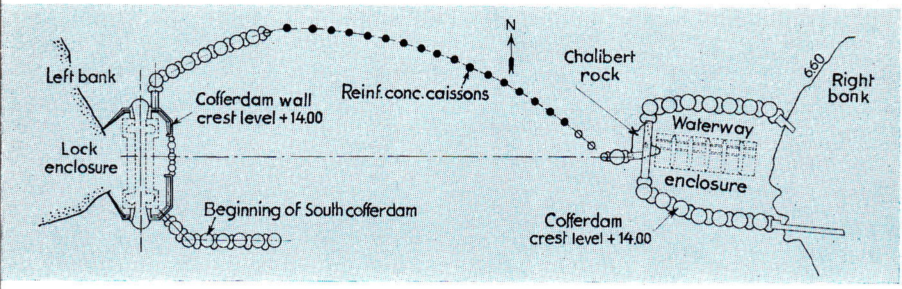
The large enclosure will be terminated, thus permitting construction of the power station and the fixed dike.

a - the lock and the waterway gates having been put into service, the Rance will be cut off by progressive closure of the spaces between the caissons of the North coffer-dam the crest level of which is + 14 S.C.
One out of every two of these spaces will be closed so as to give much more stable supports than the caissons alone, because as the breach left for the passage of the tide becomes narrower, the changes in level on both sides of the coffer-dam increase.
To facilitate construction of the sheet-piling cells between two caissons, the space will be filled in with temporary girders so as to cut off the currents. Grooves are made in the caissons for this purpose.

b - The currents having been cut off, the sluices will be closed and the water level in the estuary will be maintained at 8,50 S. C. which is sufficient to permit navigation on the Rance as far as the Le Chatellier lock.

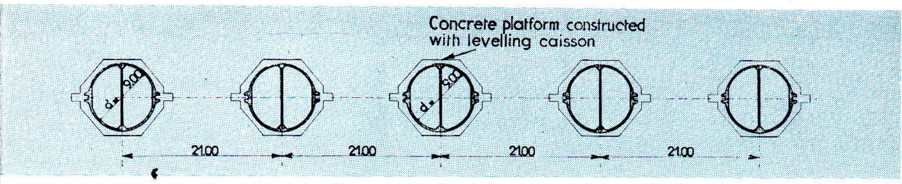
The Southern coffer-dam will be finished in still water. Formed of sheet-piling gabions, it will be levelled off at + 9.00 S. C.

This method has been adopted as a result of e
Rance built on the Terre-Plein du Nay

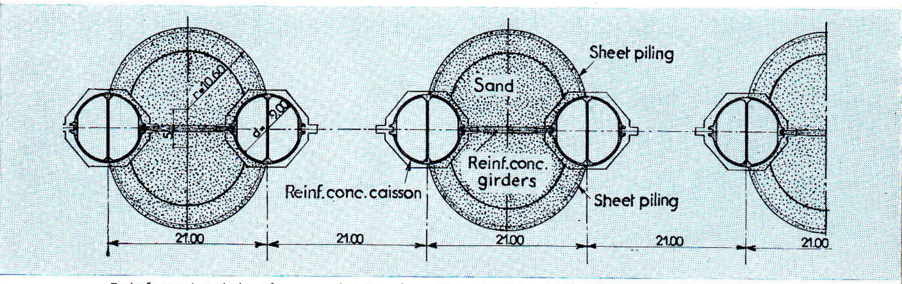


During this first stage, the implantation of a **large central enclosure** with two coffer-dams, North and South, will be begun:

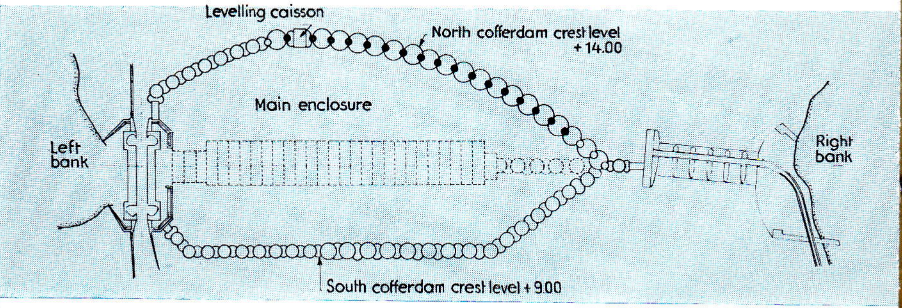
- by constructing **flat web sheet-piling gabions** filled with sand, section by section,
- by stranding **reinforced concrete caissons** on the site of the North coffer-dam, on foundations prepared in advance by means of a compressed air caisson enabling work to be carried on under the water. These caissons will be filled with sand.



Normal points of support : 1 reinf. concr. caisson, dia. 9 m



Reinforced points of support : 2 caissons and one sheet-piling cell filled with sand



xperiments on a small scale model (1/150) of the
e, alongside the St-Malo - St-Servan port.

MATERIALS USED

Temporary structures (coffer-dams)

Concrete		40 000 m^3
Sheet piling	Curtain face	90 000 m^2
	Corresponding weight	13 000 t
Filling sand		460 000 m^3

(Gabions and renforced concrete caissons)

Final structures

Earthworks	400 000 m^3
Concrete	260 000 m^3
Structural steel	10 000 t

CAPACITY AND PRODUCTION

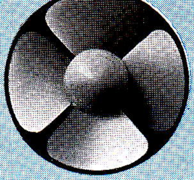
Installed power	240 MW
Net output	544 GWh

made up as follows :

basin-to-sea output	537
sea-to-basin output	71,5
Total	608,5
Power absorbed by pumping	— 64,5
Net output	544

SCHEDULE

Beginning of preparatory work	July 1960
Beginning of work on final structures	January 1961
Total duration of works	approximat. 6 years
Commissioning of first sets	as from the 5 th year



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